

## 3.

The Metamorphosis of *Synodus foetens* (Linnaeus).

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(Plates I &amp; II; Text-figure 1).

Although *Synodus foetens* (Linnaeus) is a well known and common fish along the south Atlantic coast of the United States and the postlarvae are recognized by most ichthyologists familiar with the region, it appears that only three partial descriptions of it have found their way into the literature: Nichols (1911), Beebe and Tee-Van (1928) and Norman (1935). The developmental stages are still to be described, although Sanzo (1915) gives a detailed description of the development of the similar *Synodus saurus* (Linnaeus) under the name of *Saurus griseus* Lowe. At the field laboratory of the New York Aquarium located on Palmetto Key, in Pine Island Sound, Florida, postlarval specimens may be taken irregularly at night lights at the head of the laboratory dock, at least during June and July. Such larvae are practically sub-leptocephali in form and are readily distinguished from *Isospondyli* larvae, also present, in the possession of six bilaterally paired and ventro-laterally placed internal dark blotches. Otherwise the general similarities of these postlarvae are in keeping with their evident affinities to the *Isospondyli*.

Both the young and adult of the *Synodus foetens* are common along the Florida west coast. Specimens in our collection have been taken at the following places.

LOCALITY	DATE	STANDARD LENGTH IN MM.	
Palmetto Key, north shore.	4/2/39	34-40	Recently transformed.
Boca Grande Pass.	4/28/39	29-31	Postlarval.
Palmetto Key, laboratory dock.	6-7/42	29-31	Postlarval.
Fort Myers.	3/2/43	33	Postlarval.

The egg of *Synodus saurus*, according to Sanzo (1915), measures 1.21 mm. in diameter and has a cluster of very small oil droplets and a very narrow perivitelline space. The only unknown egg taken in our

tow-net operations which even remotely resembles this is one of 1.2 mm. in diameter with a single small oil globule and a larger perivitelline space. We doubt if this is the egg of *Synodus foetens* and it seems likely that we have not taken it in our tows.

Laboratory work on this material was carried on in the Department of Animal Behavior of the American Museum of Natural History. Miss A. M. Holz, of that department, kindly prepared the cleared and stained material and made the microscopic sections necessary to the understanding of certain features of the specimens.

The transition of postlarval fishes to the adult form may proceed with extreme regularity and slowness or with considerable rapidity, in some cases amounting to practically an explosive change. We know of no case in which such a change is effected with greater rapidity than that of the planktonic postlarvae of *Synodus foetens* transforming to the bottom-dwelling adult form.

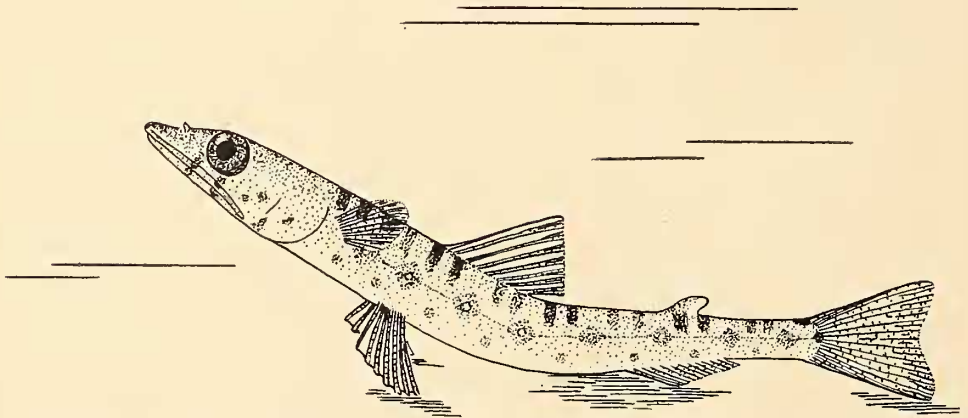
In connection with other matters, successful efforts were made to establish various *Isospondyle* postlarvae in aquaria during the summer seasons 1940, 1941 and 1942, see Breder and Krumholz (1943). Among them a single *Synodus foetens* postlarva was successfully established in a small aquarium of standing water. This specimen was captured and placed in the aquarium about 10:00 p.m. on June 19. At this time it was of glass-like transparency except for its black eyes and the six characteristic black patches. It was active and thoroughly planktonic in behavior and gave no hint of transformation. Nevertheless, by 8:00 a.m. the next morning, it had taken up residence on the bottom and showed a pale pattern on its back similar to that of the adult. From this time on its behavior was indistinguishable from that of the larger specimens that are abundant in this locality. The next day it was removed to a dish and photographed from above. This picture is given in Plate I over June 21. Here the size is indicated. Naturally it was impossible to measure the

living fish direct, but others, still planktonic, which were preserved as caught, ranged from 29 to 31 mm. in standard length. Transformed young of 34 to 40 mm. in standard length have been taken as early as March 2. This fact and visual observation give no suggestion that this species shrinks prominently, if at all, during metamorphosis as do some Isospondyle larvae, as for example *Albula vulpes*, Hollister (1936 and 1939), or as is well known among the Apodes, in the case of the leptocephalus of *Anguilla*. Growth from here on was regular until the specimen was preserved on July 10. Two further photographs were made and are shown opposite their respective dates in Plate I. This series of three photographs of the same fish well indicates the increasing intensity of pigmentation and the lack of any recognizable pattern change, as well as the generally increasing opacity of the flesh. A considerably larger specimen was also photographed in identical fashion for comparison as to the dorsal aspect of the pattern. This is given in Plate II, Figure 3. Large specimens of nearly a foot, not uncommon in this region, showed essentially the same type of pattern, although Hildebrand and Schroeder (1928), writing of specimens from Chesapeake Bay, indicate that fish of this size in that locality lack the bars across the back of the younger specimens.

The feeding of this tank-reared specimen was vigorous and the lunges that it made at passing plankton objects were notably voracious. Unfortunately there are no data on its feeding while in the postlarval stage. As its size increased it took small fishes with

equal vigor and because the quantities may not have been sufficient, it is supposed that the speed of growth may have been less than normal. Four poses of the fish as seen resting on the slate bottom of the aquarium are shown in Plate II, Figure 2. As the fish became larger it would raise up with its body at an angle as it gave attention to some passing food object. Unfortunately it was impossible to get a satisfactory photograph of this striking but transitory pose. This bending of the body, sharply in a vertical plane, increased with age. The sketch shown as Text-Figure 1 was made on July 8. It represents the extreme flexure of this type, the vertebral column bending sharply just back of the dorsal fin. Large specimens between three and six inches in length have not been seen to bend in this fashion. Although they prop themselves on the pelvis and slightly arch the back in a smooth curve of large radius, under similar circumstances, they seem to be unable to bend as sharply as the newly transformed fish. This may be a purely mechanical circumstance subject to the greater thickening of the tissues due to the increase in absolute size.

Cleared and stained specimens of the size that bend freely in a vertical plane show no skeletal modifications at the point of flexure, the numerous centra and their processes being all similar in detail from far ahead to far posterior of this region. The only difference between the successive centra of this region is the usual gradual decrease in size caudad. At this stage the vertebrae are fully ossified. Even before transformation the centra are ossified although at this earlier time the processes



TEXT-FIG. 1. Pose of newly transformed *Synodus foetens* when about to strike at a food object passing overhead.  $\times 2.91$ . This sketch, which shows the extreme of the bending in a vertical plane of which these fish are capable, was made eighteen days after transformation from a planktonic postlarva. The fish at this time was a little over 30 mm. in standard length.

are not completely ossified to their tips, as they are after transformation.

In the translucent flesh of the young transformed and patterned fish, the dark internal patches are still distinct, but in preserved material it may be seen that they are becoming overlaid by dermal pigmentation as is indicated in Text-figure 1. This figure also shows the diamond-shaped spots along the lateral line that are beginning to appear, but which cannot be seen in the dorsal-view photographs, although they show plainly in Plate II, Figure 1. It is also to be noted in nearly all the illustrations that each alternate pair of the dark saddle-like marks on the back are much darker than those intervening.

Beebe and Tee-Van (1928) describe the location of the ventro-lateral blotches as follows: "These black pigment spots lie between the gut and the peritoneum, and they are considerably more adhesive to the outer layer of tissue. The spots are upright, broad ellipses with solid edges." Dissection of the present material showed that these pigment patches were in the lining of the peritoneum. They appear to be composed of a uniform dark layer of minute pigment granules, unlike the ordinary melanophore pigmentation of young fishes. In sectioning it was found that this pigment layer was soluble in acid alcohol (3 per cent. nitric acid in 70 per cent. alcohol) and is evidently chemically different from ordinary melanin which withstands such treatment. As indicated by Beebe and Tee-Van, the spots are nearly elliptical and have sharply delimited outlines at the ventral end of the partial ellipse. In adults the peritoneum is pigmented and brownish in color down to a little below the mid-line of the visceral cavity, below which it is unpigmented. The pigmentation stops abruptly in a practically straight horizontal line.

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## EXPLANATION OF THE PLATES.

## PLATE I.

Fig. 1. Growth of a single specimen of *Synodus foetens*, from transformation of a planktonic postlarva to date of preservation, including three scale photographs of the dorsal aspect showing changes in size and extent of pigmentation.

## PLATE II.

Fig. 2. Four views of a specimen of *Synodus foetens* resting on the slate bottom of

an aquarium. Photographed thirteen days after abandoning planktonic life. This is the same fish shown in dorsal view in Plate I. The internal ventrolateral blotches may still be seen in some of these poses.

Fig. 3. A larger specimen of *Synodus foetens* of 64 mm. in standard length, on the same scale as those in Plate I, showing the increase in pigmentation with growth as well as the essential retention of the original pattern.